

LASER-ASSISTED SOLAR CELL METALLIZATION PROCESSING

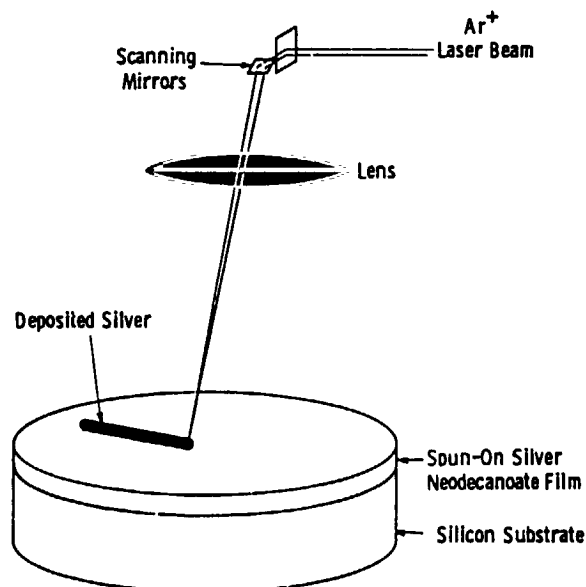
WESTINGHOUSE ELECTRIC CORPORATION
RESEARCH AND DEVELOPMENT CENTER

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Topics

- **Basic Concept**
- **Linewidth**
- **Cells Fabricated Without Masks**
- **Alternative Metals for Improved Adherence**

Laser Pyrolysis of Spun-On Metallo-Organic Film



Sample Base Temperature 75°C

Focussed Laser Spot Decomposes Spun-On Film

Silver Metallization Patterns are Formed by Direct-Writing

PROCESSING

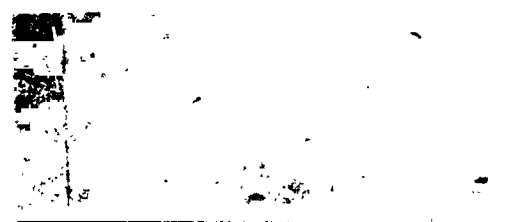
Effect of Laser Power on Laser-Metallized Linewidth After Rinsing the Silver Neodecanoate Film



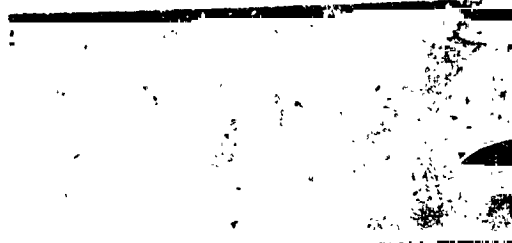
Maximum Power: 8.5 watts
Width: 60 μ m



Maximum Power: 6.9 watts
Width: 60 μ m



Maximum Power: 4.9 watts
Width: 55 μ m



Maximum Power: 4.1 watts
Width: 50 μ m

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Effect of Laser Power on Laser-Metallized Linewidth After
Rinsing the Silver Neodecanoate Film (Cont'd)



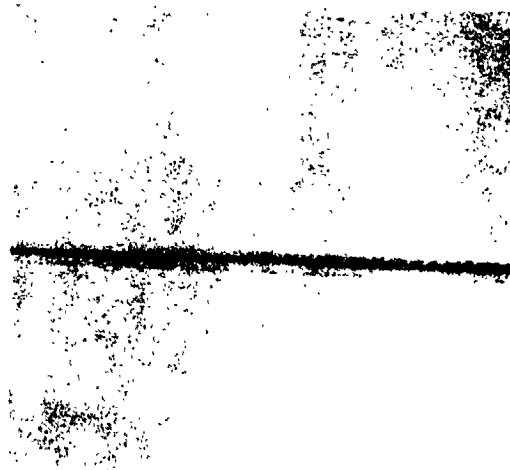
Maximum Power: 2.6 watts
Width: 40 μ m



Maximum Power: 1.8 watts
Width: 40 μ m



Maximum Power: 1.2 watts
Width: 30 μ m



Maximum Power: 0.7 watt
Width: 20 μ m

PROCESSING

Linewidths as a Function of Laser Power With 50 mm Lens Before and After Film Rinse

Laser Power (W)	Before <u>Film Rinse</u>	After <u>Film Rinse</u>
8.50	85 μm	60 μm
7.50	75	65
6.90	75	60
6.36	75	60
5.70	70	60
4.92	70	55
4.14	65	50
3.30	60	50
2.55	55	40
1.80	50	40
1.20	45	30
0.66	25	20

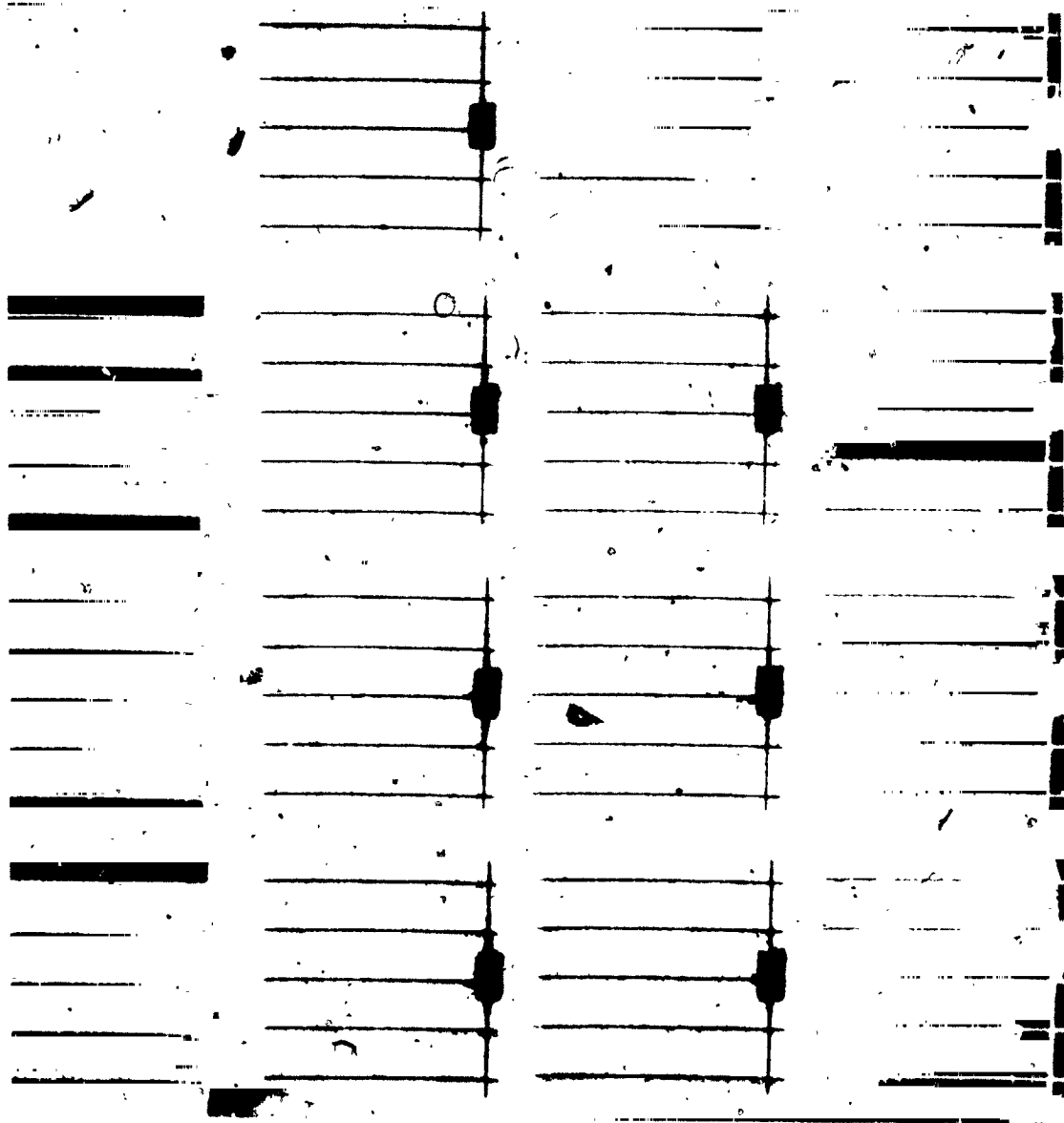
PROCESSING

Sequence of Laser-Assisted Maskless Metallization Process

- Evaporate 1500 Å Ti (adherence) and 500 Å Pd (cap) over entire Si wafer
- Spin solution of silver neodecanoate in xylene on wafer
- Write Ag lines (50 μm) with Ar^+ laser (8 W) at 20 cm/sec scan speed
- Dissolve undecomposed silver neodecanoate film in acetone
- Electroplate 8 μm Ag on laser-deposited Ag lines
- Etch Ti and Pd leaving only grid lines

PROCESSING

Laser-Metallized Cells



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PROCESSING

Effect of Laser Power on the Performance of Cells Fabricated by Laser-Assisted Metallization Process

<u>Cell ID</u>	<u>Laser Power Watt</u>	<u>J_{sc}² (mA/cm²)</u>	<u>V_{oc} (mV)</u>	<u>FF</u>	<u>η (%)</u>
1	8.5	33.5	577	.787	15.2
2	7.0	34.3	582	.792	15.9
3	6.0	34.6	579	.788	15.8
4	4.0	35.1	582	.781	16.0
5	3.0	34.9	582	.785	16.0
6	2.0	34.5	584	.786	15.9
7	1.0	34.1	573	.761	15.2

PROCESSING

Laser-Metallized Solar Cells on 4 ohm-cm Float-Zone Silicon After AR Coating

<u>Cell ID</u>	<u>J_{sc} (mA/cm²)</u>	<u>V_{oc} (mV)</u>	<u>FF</u>	<u>η (%)</u>
2	35.0	606	.754	16.0
3	34.9	603	.768	16.2
4	35.5	603	.750	16.0
5	34.8	601	.781	16.3
6	35.0	601	.779	16.4
7	35.4	603	.780	16.6
10	34.5	598	.778	16.1
11	33.8	604	.785	16.1
14	34.3	603	.789	16.3
15	34.2	604	.782	16.2
Q1+	35.1	609	.790	16.9

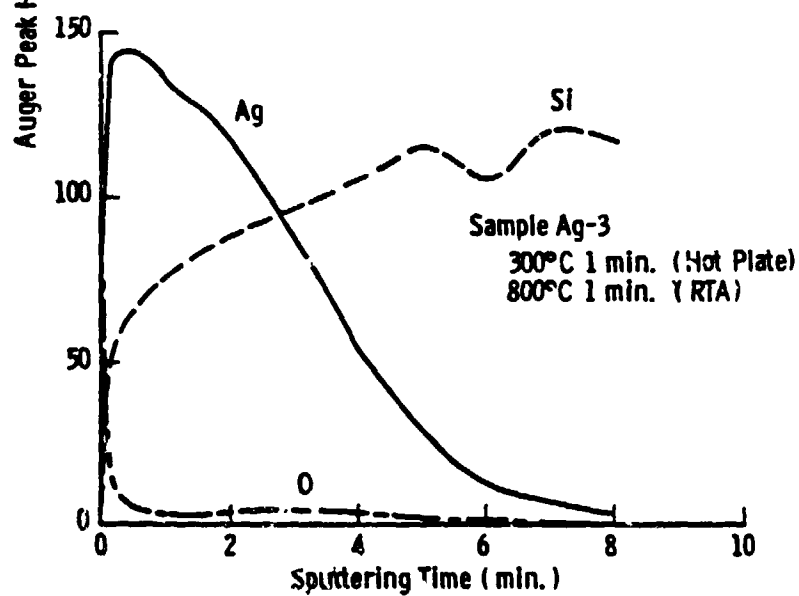
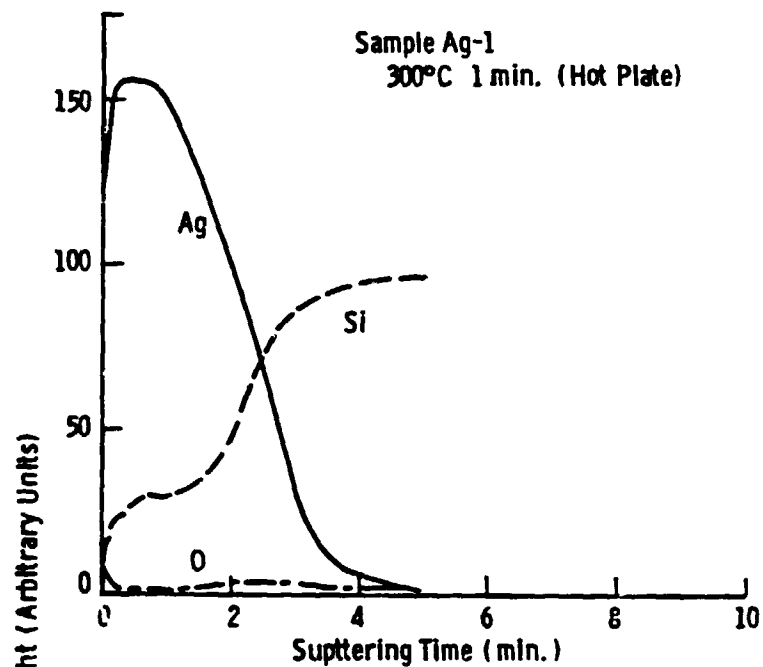
+Conventional Metallization/Lithography and no
passivation

PROCESSING

A Comparison of Lighted and Dark I-V Data of 16.6% Laser-Metallized Cell and 18.4% Cell Fabricated by Conventional Metallization and Photolithography

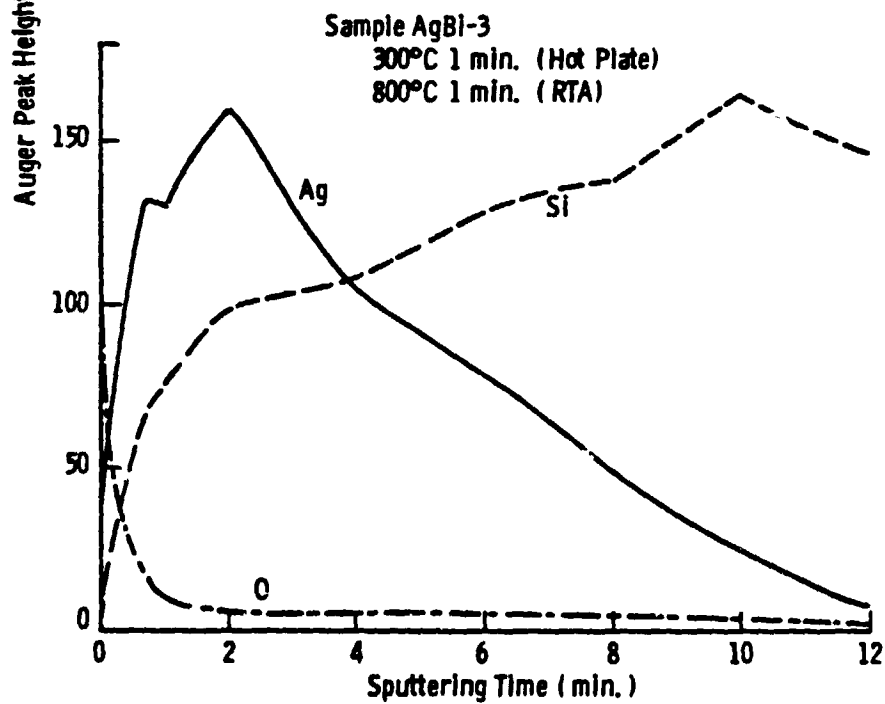
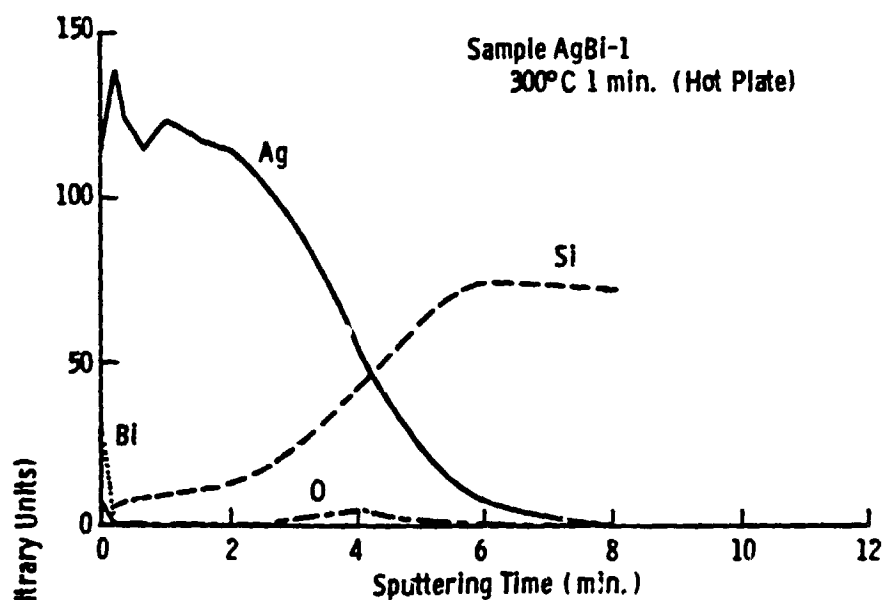
<u>Parameter</u>	<u>16.6% Laser-Metallized Cell</u>	<u>18.4% Oxide-Passivated Conventionally Metallized Cell</u>
J_{sc}	35.4 mA/cm ²	36.7 mA/cm ²
V_{oc}	604 mV	621 mV
FF	0.780	0.804
η	16.6%	18.4%
R_s	0.69 Ω -cm ²	0.56 Ω -cm ²
R_{sh}	103 k Ω -cm ²	150 k Ω -cm ²
J_o	1.4×10^{-12} A/cm ²	0.5×10^{-12} A/cm ²

Relationship of Auger Peak Height Versus Sputtering Time



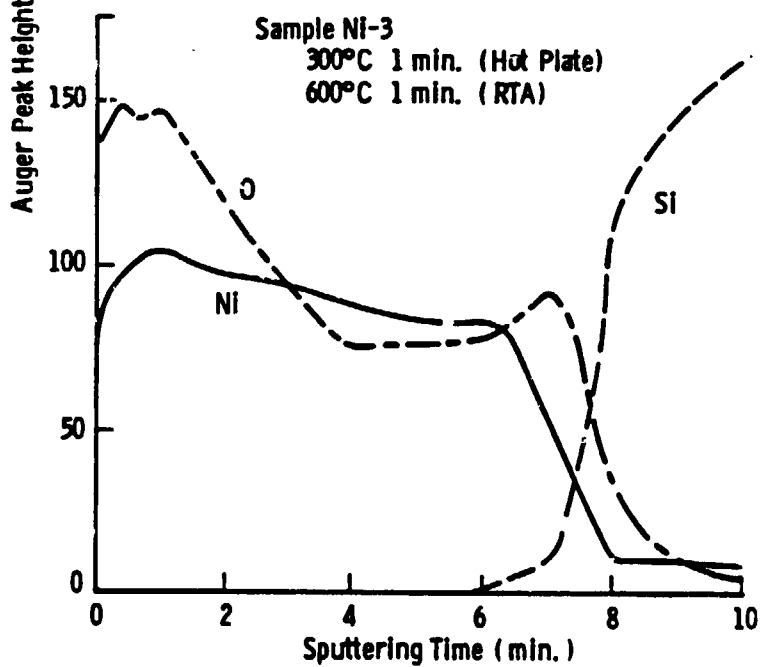
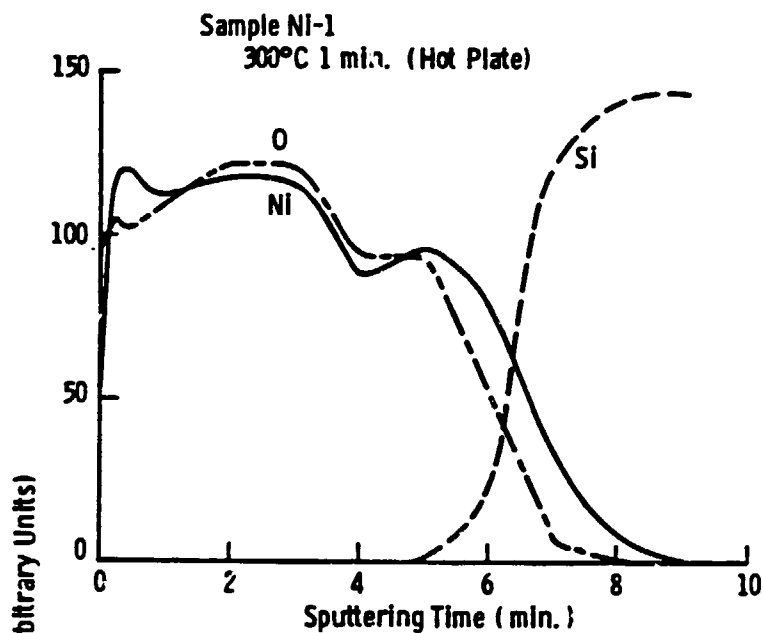
PROCESSING

Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



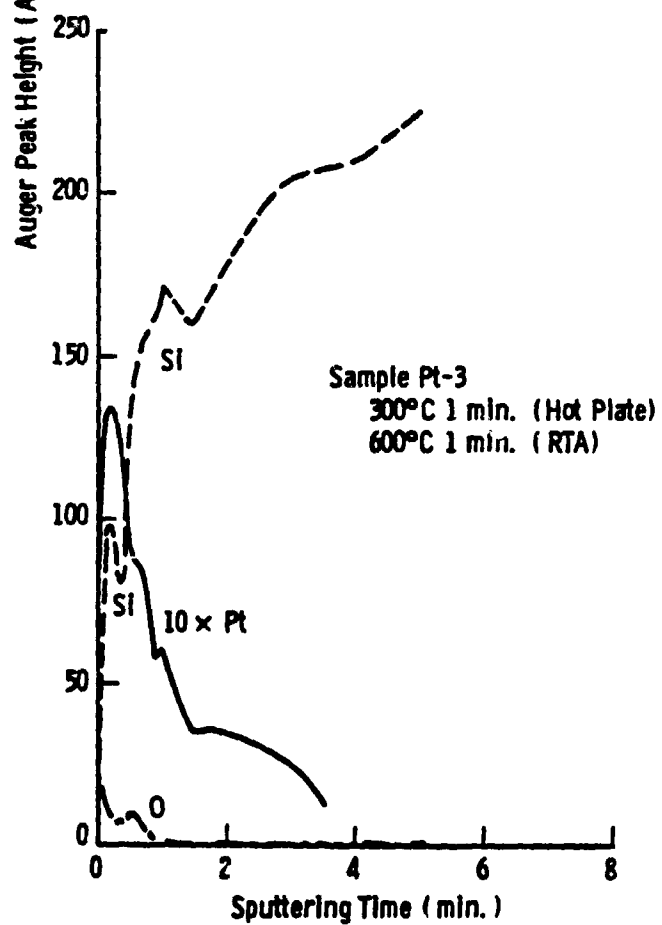
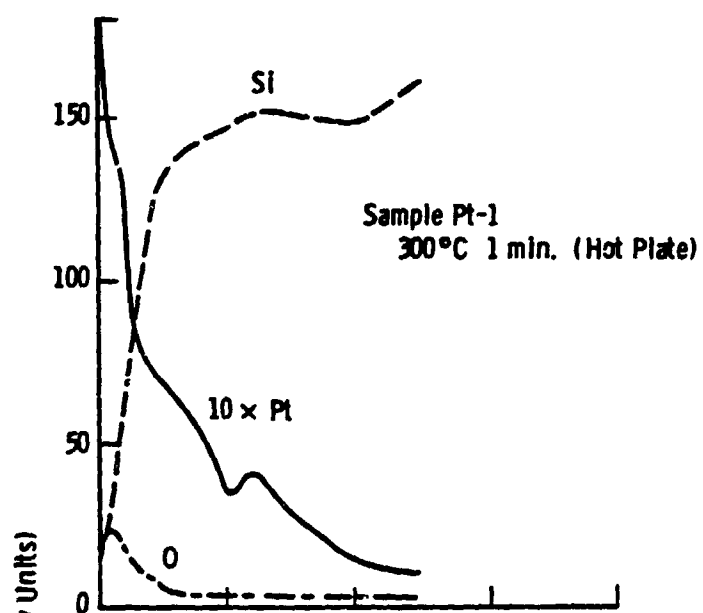
PROCESSING

Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



PROCESSING

Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



Summary

- **Linewidths of 20 μm demonstrated**
- **Cells with efficiency up to 16.6%
fabricated with a hybrid
laser/evaporation maskless process**
- **Adherence of Ag to Si poor**
- **Alternative materials (Ag/Bi, Ni,
Pt) also poorly adherent
(preliminary result)**

